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A DETERMINATION OF THE RATIO OF THE SPECIFIC HEATS OF HYDROGEN AT 18° AND -190°C.

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For the purpose of this study of the ratio of the specific heats of hydrogen the Lummer and Pringsheim method has been adapted to a one liter flask with a precision comparable with the extreme precision it has given in large carbons. The method consists essentially in obtaining γ from observation of the cooling consequent upon small adiabatic expansions by way of the ideal gas equation

$$(\rho_1/\rho_2)^{\gamma-1} = (\theta_1/\theta_2)^{\gamma}.$$

The cooling was in this case measured by a thermal element of 0.001 inches copper and constantan wires, lightly brazed at the junction, which were introduced through glass tubes drawn out inside to fine capillaries and spread nearly to the diameter of the flask, the junction being carefully placed at the center. The thermal E.M.F. developed by the expansion was measured by a null method with a Wolff potentiometer, the galvanometer sensibility being such that an equilibrium temperature could be read to 0.0002°. Because of the finite heat capacity of the junction and the surges incident to the expansion, it was necessary to observe the cooling at a constant interval of time after the expansion, the interval varying from 0.6 to 1.0 seconds in different series of observations. With a small container there is during this time a considerable inflow of heat to the thermojunction by conduction and convection and by radiation, the total inflow being a function of the time and the mounting of the individual junction. Since this inflow is also proportional to the cooling, the error due to it is eliminated by taking a series of observations for different excess pressures and plotting γ as a function of Δp atmosphere, (this must be linear for the expansions used, which did not exceed 0.04 atmosphere) and taking the limiting value of γ for $\Delta p = 0$ as the true γ .

The method was first tested for air with three different junctions which gave lines of quite different slopes, but intercepts

$$1.4014, \quad 1.4019, \quad \text{and} \quad 1.4017.$$

To this value computed from the ideal gas equation must be added a correction for internal work, 0.0012, as obtained from either the Berthelot

or the Van der Waals equation of state (cf. Partington³). The final value 1.4029, is in close accordance with the three values which have been obtained by this method in carboys of 60 to 100 liters: Lummer and Pringsheim,¹ 1.4025; Moody² 1.4003; Partington,³ 1.4032. (Moody's published value has been revised by the addition of the internal work correction and by the removal of the applied radiation correction since it was already included in the intercept.)

Data showing the same degree of uniformity were obtained in hydrogen with four different junctions, in two cases the same junctions as were tested in air. These gave respectively

$$1.4013, \quad 1.4006, \quad 1.4013, \quad \text{and} \quad 1.4017.$$

There being no theoretical correction in the case of hydrogen, the final value is 1.4012. This value, so closely, in accord with the kinetic theory, is contrary to the only previous evidence of weight, viz., 1.4084, the original determination by Lummer and Pringsheim, and 1.407 computed by Scheel and Heuse⁴ from observations on C_p , which point to a quantum effect in hydrogen even at 18°.

The development of the method in a one liter flask opened the possibility of observation with a liquid air bath, at a temperature where determinations by Scheel and Heuse on C_p and by Eucken⁵ on C_v have shown hydrogen to be virtually monatomic. By introducing a second low resistance potentiometer into the thermojunction circuit, it was found possible to make the thermometric arrangement quite as sensitive at -190° as at 18°, in spite of the fact that the thermal E.M.F. per degree is only about half as great. Observations are necessarily less precise because of the comparatively rapid change in temperature of the bath and the attendant difficulty in duplicating pressures. The final value of γ with the correction for departure from the ideal gas state added, 1.592 at a mean temperature of 82° A., is however probably correct to 0.005, and corroborates closely the work of Scheel and Heuse.

A full account of the work will appear in the *Physical Review*.

¹Lummer and Pringsheim, *Ann. Physik, Leipzig*, **64**, (536).

²Moody, *Physic. Rev., Ithaca*, **34**, (275).

³Partington, *Physik. Zs., Leipzig*, **14**, (969).

⁴Scheel and Heuse, *Am. Physik, Leipzig*, **40**, (473).

⁵Eucken, *Berlin, Sitz Ber. Ak. Wiss.*, 1912, (141).